Calculated Atomic Masses in Delta-c Mechanics

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Abstract

The purpose of this paper is to illustrate the capability of Delta-c Mechanics, and demonstrate results in nuclear structure unattainable by standard Newtonian physics, including the methodology of the Standard Model.

Delta-c Mechanics is a new formulation of physics with a broad range of applicability. While the author's recent papers [1][2][23], have primarily focused on applying the theory to problems already addressed by standard physics, yielding results that, though derived through the novel methods, are not new. This work seeks to highlight its unique potential. Specifically, to show how Delta-c Mechanics provides a clear and definitive framework for nuclear particle mass, with capability that has no equivalent in Newtonian or QM physics.

In Arthur Eddington's book from1936 on photons and electrons, he observed that the wavefunctions of particles are multiplicative rather than additive. Based on this insight, he suggested that mass, like wavefunctions, might also arise as a product of its components rather than as their sum.

Delta-c Mechanics offers a framework where the relative masses of nuclear particles are entirely determined by the product of their constituent masses. This approach aligns with Eddington's view and provides a rigorous, mathematically grounded method for understanding mass relationships at a fundamental level.

By focusing on multiplicative principles, Delta-c Mechanics reveals new insights into the nature of mass and its role in particle physics, setting it apart from conventional theory.

Feynman's formulation of QED is based on the principle that particles, take all possible action paths from vertex to vertex by summing amplitudes over all possible paths and obtaining the probability amplitude of the path.

Particles are the vertex of bound states and are poles in QED amplitudes. At the poles the path integrals fail and are replaced with boundary conditions that match particle properties. The point at the vertex of the Feynman has conservation rules regarding the energy and particles in and out, but does not define the interior mechanisms of the vertex. Delta-c mechanics can define the interacting structure of the particle regarding the mass and probability density generated at the vertex, thus is able to define the relative mass of nuclear particles.

Topics

Vertex Functions

The structure of the vertex identified as a Vertex Function is composed of a product of a number of vertex kernels. A Vertex Kernel is the structure of the interacting probability density of electrons or neutrinos that can exist in various state conditions in units of Planck's constant.
The “Vertex Function” is the product of a collection Vertex Kernels that make up the mass of nuclear particles. The Vertex Kernels could said to be sub particles of a composite particle that define the probability density of the location of a sub-particle as a function of the distance from that particle. Originally this was developed in [8] for two electrons, it is clear now that it has general application for a multiplicity of nuclear particles.
With particles defined in Kernels, and the Vertex Function defined for a number of particles, the decay components can be identified including that of the neutrino.

The proposed structure of the neutrino is developed in Part Two of this paper.

Structure of Elementary Nuclear Particles

In previous research, the mass values of particles within the atomic nucleus have been presented, however, this paper aims to delve deeper by exploring the internal structure of these particles and elucidating why elementary mass particles exhibit specific, quantifiable values. The foundational studies, *"Nuclear Particle Structure in Delta C Mechanics"* and *"Neutrino Binding Between Nuclear Particles in Delta-C Mechanics"* [13][27], laid the groundwork for this ongoing investigation, providing the initial direction for understanding nuclear particle structure [2].

Preliminaries

Photons & and particles

Delta-c Mechanics postulates the photon is a rotating Planck particle having a radius of $\lambdabar_{PL}$ (10E-33 cm), and a probability flow direction rotating at the Compton frequency, having energy of $\varepsilon = \hbar\omega$. If the photon is not in rotation, it has no energy, but still has an interaction with the probability flow of other photons by virtue of its cross section, changing the flow direction, thus having an effect on the index of refraction and the probability flow of other photons.
The primary rest mass particle is the electron, formed by the self-binding of two photons which having sufficient probability flow to direct, by the change in the index if refraction of the other, into an orbit (See [5] for details). The change in the velocity of light near a rotating particle due to the probability of its photon location is given by:

$$\frac{\Delta c}{c_0} = \left(\frac{\lambda\!\!\!^{-}_{PL} \bar{\nu}_e}{r} \right) \tag{1}$$

This is the elemental Vertex Kernel that provides both the probability density and the cross section of an electron. This is also the change in the velocity of light at a distance r from the rotation of a Planck particle at the repetition rate of the electron.
The product of two Electron Vertex function yields the product of the probability density of the two particles, and in turn the mass generated by the interaction.

$$\frac{\Delta c}{c_0} = \frac{\Delta \varepsilon}{\varepsilon_0} = \frac{1}{2}\left(\frac{\sqrt{2}\lambda\!\!\!^{-}_{PL} \bar{\nu}_e}{r} \right)\left(\frac{\sqrt{2}\lambda\!\!\!^{-}_{PL} \bar{\nu}_e}{r} \right) = \left(\frac{\lambda\!\!\!^{-}_{PL} \bar{\nu}_e}{r} \right)\left(\frac{\lambda\!\!\!^{-}_{PL} \bar{\nu}_e}{r} \right) \tag{2}$$

This relation shows the change in the velocity of light at one particle at a distance r from the other, and giving the interaction energy $\Delta\varepsilon$ as a result of the particle biding $\Delta\varepsilon$ is the deficit in energy created by the binding, and is radiated away when the particles have

a an integral $\hbar$ solution, $n\hbar = mcr$. The numerators in Equation(2), are identified as the Electron Creation Radius [5]. $\Re_0$ is the radius that the two photons in the electron orbit each other.

$$\Re_0 = \sqrt{2}\lambda\!\!\!^{-}_{PL} \bar{\nu}_e = 2.82447977709503\text{E}-13 \text{ cm} \tag{3}$$

This as well as others constants are used in Delta-c Mechanics, they are not arbitrary, but a composition of fundamental constant, all of which are included in Appendix II
The radius $\Re_0$ is composed of the Planck particle radius $\lambda\!\!\!^{-}_{PL} = \sqrt{G\hbar / c^3}$, and, $\bar{\boldsymbol{\nu}}_e$, which is termed the Electron Rotation number. $\bar{\boldsymbol{\nu}}_e$ is the ratio of the velocity light travels in free space, to the relative velocity of the photons, v_e, in the creation orbit of the electron. It is "unitless" but its magnitude is equivalent to the Compton Electron Frequency ν_e.

$$\nu_e = \frac{c_0}{\lambda\!\!\!^{-}_e} \qquad \bar{\boldsymbol{\nu}}_e = \frac{c_0}{\text{v}_e} \quad \rightarrow \quad |\nu_e| = \bar{\boldsymbol{\nu}}_e \tag{4}$$

The velocity v_e is the velocity of light for the bound photons in the core of the electron slowed down by the binding probability density of the other.
The relations in Eq(4)., are developed in [5].

The Nuclear Atomic Ground State

Stable solutions to particle interactions exist when the radius of a particles rotation is such that the angular momentum is an integral number of the action quantum $\hbar n$, or $\hbar / n$. The ground state of atomic and nuclear particles exists at the Compton radius of the free electron.

$$E_0 = \frac{1}{2}\left(\frac{\Re_0}{\lambda_e}\right)^2 = \frac{1}{2}\left(\frac{\Re_0 m_e c_0}{\hbar}\right)\left(\frac{\Re_0 m_e c_0}{\hbar}\right) \tag{5}$$

The ratio: $\Re_0 m_e c_0 = \hbar / 136.71872288679$, (6)

is the ratio of the angular momentum of the orbiting photons in the electron creation radius that form the electron, to the Planck action quantum, $\hbar$. This is the actual physical angular momentum of the free electron, not the relative value of $\hbar / 2$ assigned to Fermions.

$$\Re_0 \left[p_1 + p_2\right] / \hbar \qquad\qquad p_1 + p_2 = m_e c_0 \tag{7}$$

This is a fundamental constant and all numbers are known to at least 10 significant places. All integers used in this paper are multiplies or divides of $\hbar$, and do not change the calculated accuracies. This state marks the ground state of both atomic and nuclear particles, and there are no arbitrary adjustable factors.

The value of the binding of two electrons, Eq.(5), one positive and the other negative, forms the ground state of the atomic-nuclear, particles. The value of E_0 is the unitless ratio, of the state energy of two $\pm$ bound electrons, reference to the mass of an electron.

The Rydberg energy ground state of atomic particles is not exactly at the radius λ_e, but because of the QED loop induced delay in the completion of the electron Compton radius of two orbiting electrons; the radius is greater by the factor of the Anomalous Gyromagnetic Ratio g_A, (See EQ(12)). The base state radius is at the Compton radius of the electron, but the gyromagnetic ratio which is a delay of orbital completion due to the probability loops, increases the Rydberg base radius of atomic particles to $r = \lambda_e g_A^2$, which establishes the ground state of atomic particles.

When this radius is set as the solution to Equation(2) , the energy levels are the ionization energy of two opposite $\pm$ electrons or twice the ionization energy of positronium,

$$\frac{E_0}{g_A^4} = \frac{1}{2}\left(\frac{\Re_0}{\lambda_e g_A^2}\right)\left(\frac{\Re_0}{\lambda_e g_A^2}\right) = \frac{1}{2}\alpha^2 \rightarrow \ 13.606 \text{ eV} / m_e \tag{8}$$

The difference in this and the hydrogen ionization is the inclusion of the reduced mass in the hydrogen atom.

The Rydberg integer n_R, which represents integral values of the quantum of action $\hbar$, can be included in this expression, defining the atomic levels:

$$\frac{\Delta\varepsilon}{\varepsilon_0} = \frac{\alpha^2}{2} \to \quad \frac{m_X}{m_e} = \left(\frac{\alpha^2}{2n_R^2}\right) \tag{9}$$

The energy radiated away when the electron occupies the states is $m_e\left(\alpha^2 / 2n_R^2\right)$, which is the reduction in the mass of the electron occupying this position.

Note from this relation The Fine Structure Constant is a composite constant, and can be evaluated with Eq.(3), and Eq.(8), the product of fundamental constant is not arbitrary.

$$\alpha = \left(\frac{\lambdabar_{PL}\overline{v}_e}{\lambdabar_e g_A^2}\right) = 1/137.035999710 \tag{10}$$

Since α is the most accurately known number in this group, this relation is used to calculate the value of the Planck particle radius, and is:

$$\lambdabar_{PL} = 1.61640095996445E-33 \text{ cm} \tag{11}$$

This function, Eq.(8), shown with the value of the Rydberg integer $n_R = 1$, is central to both atomic and nuclear particles. While hydrogen atomic states exhibit only two particles in the binding, nuclear particles demonstrate multiple bindings of particles with the similar Kernels. The multiplicity defined by the Rydberg integer, n_K in Equation(8) is present in the structure of atomic particles as well as nuclear particles.

Structure of Nuclear Particles

It is proposed that all particles are composed of the bindings of functions designated as kernels; one being the Electron Kernel, K_A for atomic bound particles, and the other, the Nuclear Kernel, K_N for nuclear bound particles,

The base state of all particles as discussed is E_0 that is the binding energy of two free electrons (Equation(8)). States that have energy less than E_0 are atomic and states that have energy values greater than E_0 are nuclear states (particles). The Compton radius of the Rydberg atomic ground levels is slightly larger than the free electron $\lambdabar_e$ due to the QED induced rotational delay of the Anomalous Gyromagnetic ratio g_A,such that $\lambdabar_R = \lambdabar_e g_A^2$.

Anomalous Gyromagnetic ratio g_A

There are two anomalous ratios that play a role in nuclear-atomic systems, particularly the mass of the neutrinos. They are the QED determined loop integral delay for particles moving in a circle. The ratio has no effect on the free electron, but when it is bound in rotation the Feynman action integral loops cause a delay that alters the electrons Compton radius. For atomic or Rydberg levels with radii above the electron, at $r = ƛ_e g_A^2$, the Anomalous Gyromagnetic ratio g_A^2 increases the electron Compton radius. Its value is:

$$g_A = 1.0011596521807 \tag{12}$$

Anomalous Nuclear ratio η

The second is a similar factor that applies to particles with Compton radii less than $\Re_0$, it is here designated as Eta. η. The value can be determined with precision by relations between the mass of several elementary particles and it is:

$$\eta = 1.00060014721177 \tag{13}$$

For nuclear particles, with Compton radii less than $\Re_0$, it is found that the QED effect on the Compton radius η is about ½ that of the Anomalous Gyromagnetic ratio. (i.e. $\eta^2 \approx g_A$)

The Anomalous Nuclear ratio Eta η represents the change in the Compton radius for a mass particle, $ƛ'_X = ƛ_X \eta$ bound within the nucleus. This factor is consistently present in the mass of all nuclear states. As the value of the Anomalous Gyromagnetic ratio is very precise, this constant is also very precise. Eta (η), is exact to at least twelve significant digits and uniform across all nuclear particles. The exponent of Eta $\eta^{\pm n}$ depends on the number of mass particles bound, and the sign depends on relative spin. Although the value of η has not yet been determined by QED methods, it should not be dismissed as arbitrary, as it is crucial to the precise mass of several interconnected known particles. This factor, like the Anomalous Gyromagnetic ratio represents an offset to the nuclear ground state. It alters the probability density of the kernel. If it were not for these anomalous factors the state values of atomic and nuclear particles would not exist. (The relation of η to the mass of the neutrino is shown in – Part two)

Part One

The Particle Kernels

The form of the functions in Equation(9) , are the Kernel of atomic and nuclear particles K are defined as:

$$K_A = \left(\frac{\lambda_{PL}}{\lambda_e g_A^2} \frac{\overline{v}_e}{n_R} \right) \qquad K_N = \left(\frac{\lambda_{PL}}{\lambda_e \eta} \frac{\overline{v}_e}{n_N} \right) \tag{14}$$

Electron Kernel Quark Kernel

These are the core probability density or the two photon electron, the product of which establish the energy of the interaction or the value of the interaction particle masse. Note that, the Rydberg integer n_R, is a multiple of the action quantum, $\left(n_R \lambda = (n_R \hbar) / mc \right)$, and n_N plays the same role in a nuclear kernel n_N. The kernels are the same accept for the QED effects. The value of η in the kernel can be $\eta^{\pm n}$ indication an increase or decrease in the electron radius, presumably the result of the relative spin between different particles. The difference in the two kernels is the QED effects induced by their position and thus the core **of all particles, is an electron.**

Binding Mass

The ratio of the binding energy of two free electrons to the binding of a two x particles, yields the x particles mass to the mass of the electron. The binding of two particles is always the binding of a particle and an antiparticle.

The reciprocal of the root of the binding energy gives the state energy or the mass of the particle in that state.

$$\frac{E_X}{E_0} = \frac{\frac{1}{2}\left(\frac{\Re_0}{\lambda_X} \right)^2}{\frac{1}{2}\left(\frac{\Re_0}{\lambda_e} \right)^2} \rightarrow \left(\frac{E_X}{E_e} \right) = \left(\frac{m_X}{m_e} \frac{m_X}{m_e} \right) \rightarrow \sqrt{\frac{E_X}{E_0}} = \frac{m_X}{m_e} \tag{15}$$

E_0 is the ground state of the nuclear-atomic system. E_X is the state of atomic and nuclear particles referenced to the ground state. It is the square of the mass of the particle occupying the state.
The ratio in Equation(15) is the binding energy of the positive & negative x particle and base state relative to the ground state energy. The last term, is the expression for the mass of the single x particle.

Structure of Vertex Particles

As atomic bindings creates a state particle, namely photons, from the binding of two electrons, the binding of two or more sub-particles defined by the Kernels in Equation(14) can create state particles at vertex locations. These are the particles that occupy the vertex positions in Feynman diagrams, and will be referred to as Vertex Functions. The states of atomic particles are directly proportional to the product of the vertex kernels and the nuclear, states are inversely proportional.

Atonic Kernel **Nuclear Kernel**

$$\frac{E_X}{E_0} = \left[(K_{A1})(K_{A2})\right] \qquad \frac{E_X}{E_0} = \frac{1}{(K_{N1})(K_{N2})(K_{N3})}$$

$$\frac{m_X}{m_e} = \sqrt{\left[(K_{A1})(K_{A2})\right]} \qquad \frac{m_X}{m_e} = 1 / \sqrt{(K_{N1})(K_{N2})(K_{N3})} \qquad (16)$$

The magnitude of the difference in the atomic and nuclear kennels effect on the vertex function can be illustrated as:

Atonic Kernel **Nuclear Kernel**

$$\frac{m_X}{m_e} \approx \frac{\Re_0 m_e c_0}{\hbar\, n} \sim \frac{1}{136\,n} \qquad \frac{m_X}{m_e} \approx \frac{1}{\frac{\Re_0 m_e c_0}{\hbar n}} \sim \frac{136\,n}{1} \qquad (17)$$

The Atomic Kernel in the vertex function is the ratio of angular momentum of the electron at the Electron Creation radius and the action quantum $\hbar$ The Nuclear Kernel in the vertex function is the reciprocal of the atomic Kernel and is 6 orders of magnitude greater thus the nuclear masses are far larger than the reduced electrons of the atomic states

For particles such as the pion or the free neutron the vertex function are products of product of both the atomic and nuclear kernels; Meaning that the atomic vertex represents particles in the Compton radius whereas the nuclear kernels are particles bound in a radius orders of magnitude smaller.

$$E_X = E_0 \frac{\left[(K_{A1})(K_{A2})\right]}{\left[(K_{N1})(K_{N2})(K_{N3})\right]} \qquad \frac{m_X}{m_e} = \sqrt{\frac{\left[(K_{A1})(K_{A2})(K_{A3})\right]}{\left[(K_{N1})(K_{N2})\right]}} \qquad (18)$$

The difference in atomic and nuclear particles is that in the atomic case the photons state value radiates away the energy, reducing the mass of the bound particle, but for a nuclear particle the energy radiated away exceeds the free particle rest mass and the bound particles are electrons trapped as deficits in energy. All sub particles have the same kernel as electrons with the difference being the QED factors g_A and η. The atomic binding energy of the K_A particles Eq.(16), is directly proportional to product of the kernels, whereas the binding energy of the K_N components is inversely proportional. Product of the two, signify combinations of nuclear and atomic bindings.

(There is a discussion of deficit energy in Appendix III)

The simplified result of the internal mass of the particles could be stated as:

$$\left(\frac{m_e}{m_X}\right)^2 = \left(\frac{m_e}{m_1}\right)^2 \left(\frac{m_e}{m_2}\right)^2 \left(\frac{m_e}{m_3}\right)^2 \tag{19}$$

The mass of m_X is not the sum of the internal particle mass, but the product. In disintegration these individual vertex can bind with others to form temporary particles.

Calculated Mass Values

The vertex functions of several primary particles have been discovered and are presented below, the accuracy of all, but the muon is within experimental tolerance. The muon is out by an unexplained one part in 1/4 of a million.
The fundamental constants as well as the mass values used in the calculations are included in Appendix II, from Codata, and the Particle Data Groups.

The particles calculations illustrated are for:

Proton, Neutron Tauon, Muon, Charged Pion,
Z Boson, W Boson, Top Quark

Summary

Particle Mass in Electrons

	Calculated from Theory		Experimental, Codata, & PDG	
	Mass	GeV	Mass	
Proton	1836.15267344		1836.15267344	
Neutron	1838.68366173		1838.6838346173	
Tauon	3477.18825		3477.135 +/- .136	
Muon	206.76743435		206.76828298	
Pion+/-	273.131906		273.1321133	
Z Boson	177190.369	90.544	90.04 - 90.76	GeV
W Boson	157359.58	80.410	80.433 +/-.0009	GeV
Top Quark	336153.82	171.7225	171.77 +/- 038	Gev

Particle Vertex Functions and Calculated Rest Mass

Proton
1836.15267344

$$\left(\frac{m_P}{m_e}\right) = 1\Big/\sqrt{\left(\frac{\bar{\lambda}_{PL}\eta^3}{\bar{\lambda}_e}\frac{\bar{\nu}}{2^6}\right)\left(\frac{\bar{\lambda}_{PL}\eta^3}{\bar{\lambda}_e}\frac{\bar{\nu}}{1}\right)^{1/2}\left(\frac{\bar{\lambda}_{PL}\eta^3}{\bar{\lambda}_e}\frac{\bar{\nu}}{2}\right)^{1/2}} \tag{20}$$

Neutron
1838.68366173

$$\left(\frac{m_N}{m_e}\right) = \sqrt{\frac{\left(\dfrac{\bar{\lambda}_{PL}\bar{\nu}}{\bar{\lambda}_e\eta^3}\right)}{\left(\dfrac{\bar{\lambda}_{PL}\bar{\nu}}{\bar{\lambda}_e g_A^3}\right)}}\;\frac{1}{\sqrt{\left(\dfrac{\bar{\lambda}_{PL}\eta^3\bar{\nu}}{\bar{\lambda}_e 2^6}\right)\left(\dfrac{\bar{\lambda}_{PL}\eta^3\bar{\nu}}{\bar{\lambda}_e}\right)^{1/2}\left(\dfrac{\bar{\lambda}_{PL}\eta^3\bar{\nu}}{\bar{\lambda}_e 2}\right)^{1/2}}} \tag{21}$$

Muon
206.76743435

$$\left(\frac{m_\mu}{m_e}\right) = 1\Big/\left[\frac{1}{\sqrt{2}}\left(\frac{\bar{\lambda}_{PL}}{\bar{\lambda}_e\eta}\frac{\bar{\nu}_e 2^4}{}\right)\left(\frac{\bar{\lambda}_{PL}}{\bar{\lambda}_e\eta}\frac{\bar{\nu}_e 2^4}{}\right)\right] \tag{22}$$

Tauon
3477.18825

$$\left(\frac{m_\tau}{m_e}\right) = 1\Big/\sqrt{\left(\frac{\bar{\lambda}_{PL}}{\bar{\lambda}_e}\frac{\bar{\nu}_e}{}\frac{\eta^3}{1}\right)^2\left(\frac{\bar{\lambda}_{PL}}{\bar{\lambda}_e}\frac{\bar{\nu}_e\eta^3}{1}\right)^{1/4}\left(\frac{\bar{\lambda}_{PL}}{\bar{\lambda}_e}\frac{\bar{\nu}_e}{2}\frac{\eta^3}{}\right)^{3/4}} \tag{23}$$

Charged Pion
273.131906

$$\left(\frac{m_{\pi+}}{m_e}\right) = \frac{\sqrt{2}\left(\dfrac{\bar{\lambda}_{PL}}{\bar{\lambda}_e g_A^2}\dfrac{\bar{\nu}_e}{1}\right)}{\left(\dfrac{\bar{\lambda}_{PL}\bar{\nu}_e}{\bar{\lambda}_e\eta^2}\right)^2} \rightarrow = \frac{\alpha}{\left(\dfrac{\bar{\lambda}_{PL}\bar{\nu}}{\bar{\lambda}_e\eta^2}\right)^2} \tag{24}$$

Z Boson
177190.369
90.544 GeV

$$\left(\frac{m_Z}{m_e}\right) = \frac{1}{2}\times 1\Big/\sqrt{\left(\frac{\bar{\lambda}_{PL}\eta^3}{\bar{\lambda}_e}\frac{\bar{\nu}_e}{1}\right)^2\left[\left(\frac{\bar{\lambda}_{PL}\eta^3}{\bar{\lambda}_e}\frac{\bar{\nu}_e}{2^6}\right)\left(\frac{\bar{\lambda}_{PL}\eta^3}{\bar{\lambda}_e}\frac{\bar{\nu}_e}{}\right)^{1/2}\left(\frac{\bar{\lambda}_{PL}\eta^3}{\bar{\lambda}_e}\frac{\bar{\nu}_e}{2}\right)^{1/2}\right]} \tag{25}$$

$$\left(\frac{m_Z}{m_e}\right) = \frac{1}{2}\left(\frac{m_P}{m_e}\right)\times 1\Big/\left(\frac{\bar{\lambda}_{PL}\eta^3}{\bar{\lambda}_e}\frac{\bar{\nu}_e}{1}\right)$$

W Boson
177190.369
80.410 GeV

$$\left(\frac{m_W}{m_e}\right) = 1\Big/\sqrt{\left(\frac{\bar{\lambda}_{PL}\bar{\nu}_e\eta^3}{\bar{\lambda}_e 2^{11}}\right)\left(\frac{\bar{\lambda}_{PL}\bar{\nu}_e\eta^3}{\bar{\lambda}_e 2}\right)^{1/2}\left(\frac{\bar{\lambda}_{PL}\bar{\nu}_e\eta^3}{\bar{\lambda}_e 2}\right)^{1/4}\left(\frac{\bar{\lambda}_{PL}\bar{\nu}_e\eta^3}{\bar{\lambda}_e}\right)^{1/4}} \tag{26}$$

Top Quark
336153.82
171.7225GeV

$$\left(\frac{m_{TOP}}{m_e}\right) = 1\Big/\left(\frac{\bar{\lambda}_{PL}\eta}{\bar{\lambda}_e}\frac{\bar{\nu}_e}{3}\right)^2 \tag{27}$$

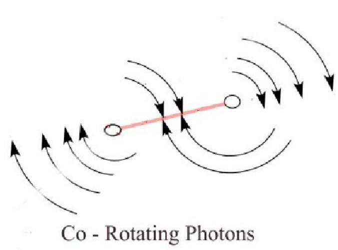
Summary - Part One

Without any injected coupling constants, the mass numbers are exceptionally accurate. Of the calculated mass values presented only the muon mass is out of experimental tolerance by an unexplained, one part in ¼ of a million.
Earlier papers have focused on the physical aspects of Delta-c Mechanics [1], [2]. This paper's intention is to extend the foundational understanding of particle mass by focusing on the structure of the mass particles and the mechanical interactions.
Finding that nuclear particles inertial mass is created by a deficit of energy (Appendix III), produces an understanding of the balance of energy in the universe between electromagnetic and inertial mass. $-\varepsilon = mc_0^2$. A proton is actually the same as two positrons and an electron, trapped as an energy deficit of 1833.15 electrons.

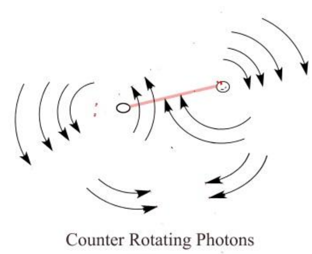
Part Two
Neutrino Mechanical Structure

The mechanical structure of the neutrino described here is a bit speculative, but the vertex energy appears to be quite accurate.
The structure of the neutrino is similar to the electron; accept that in the electron the rotating bound photons move in opposite directions around a center of mass. The external Feynman photon probability density rotates in the same direction and thus provides particle interactions. For the neutrino, the photon density moves in the same direction with internal Compton rotational directions that are opposite, but also rotate around the center of momentum. The exterior probability flow for the Compton rotation cancels the Compton radius, and particle-particle interaction.

In the paper on the Dirac equation [24], it was noted that for particle dynamics there are three parts of the energy; the inertial, the kinetic, and the total, that can be found as the magnitude of the of the Four differentials. For the neutrino the kinetic is the sum of the moving photons and the inertial is the rotary energy of the photons about the center of momentum.

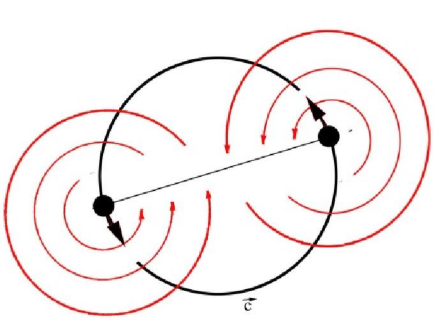


Electron
Fig.1a.



Neutrino
Fig. 1b.

For the electron, photons rotate around a stationary center of mass,(Fig 1a) bound by the reduction in the index of refraction induced by the mutual flow of their probability density. This interaction is planar and the rotatory probability flow density is parallel to the velocity vector.



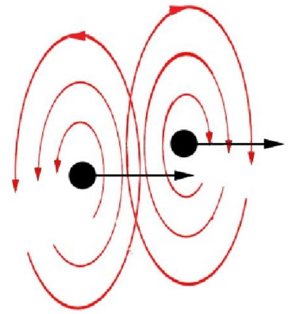


Fig2a. Electrom Fig 2b. Neutrino

The neutrino is composed to two opposite rotating, photons, bound together with parallel trajectories helictically rotating around the center of momentum. The photons are rotating around each other thus canceling the probability density flow exterior to the radius of rotation. The energy of the photons is equal to the two photons in the electron thus the sum of the electromagnetic energy is equal to the mass of an electron.

The photons of the neutrino, (Fig 2b) are moving linearly around a helical path at the velocity of light. The forward velocity is retarded by the path delay as the result of the rotational transverse component; The rotary motion component is an energy of the neutrino that is not altered by a velocity transform along the rotary axis, thus having the property of an inertial mass.

Neutrino Helictical Photon Paths

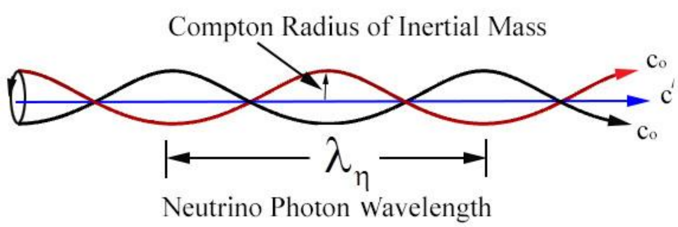
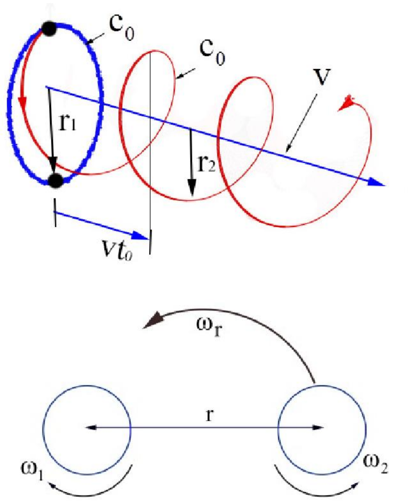


Fig 3



(showing only one photon)

ω_r is the angular velocity of the transverse rotation

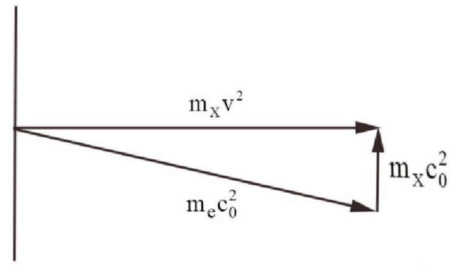
Fig.4

Helictical Projections

The energy components an be graphically illustrated as the trajectory of the photons projected from the cylinder onto a plane giving, a pictoral view of the velocity mass relations.

Relativistic Moving Electron

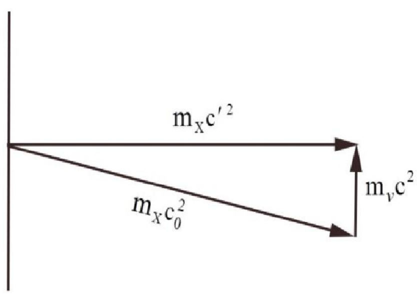
$$m_e c_0^2 = m_X\left(c_0^2 + v^2\right) \qquad m_X c_0^2 = \frac{m_e c_0^2}{\left(c_0^2 + v^2\right)}$$



The Neutrino energy

For the rotating photons in the neutrino, (Fig. 4) The revolvin c_0, moving around a cylindrical trajectory. The velocity of the center of momentum define its kinetic velocity, which is moving at a velocity less than c_0,. The relationship between the components can be found by observing the frequency as it revolves.

The rotating photon, c_0 frequency is:



$$\omega_x = \frac{c_0}{\lambda_n} = \frac{(m_X c_0)c_0}{\hbar} \tag{28}$$

The Kinetic frequency is:

$$\omega' = \frac{c'}{\lambda'_2} = \frac{(m_x c')c'}{\hbar}, \tag{29}$$

rotary frequency, and energy is:

$$\omega_r = \frac{c}{\lambda_r} = \frac{(m_r c)c}{\hbar} = \frac{m_r c_0^2}{\hbar} \tag{30}$$

A Lorentz velocity transform along the center of momentum creates a Doppler change in the energy of the photons, but the rotating angular component does not change as a result of the motion. The rotary component is independent of the shift, and thus defines a constant energy component, or rest mass. It is presumed that mass is related to the rotating frequency $m_r = \hbar\omega_r$, and is the rest mass of the neutrino.

$$m_E\left(c_0^2 - c'^2\right) = m_r c_0^2 \tag{31}$$

The angular frequency of the rotation of the photons around the axis matches the frequency of the linear projection on a plane, but the rotational radius and thus the rotational velocity is independent of the photon energy. The radius of the rotation is it is found by initial conditions producing a rest mass of the neutrino. The total energy of the neutrino is developed in the section below on the vertex functions.

Vertex Energy of the Neutrinos

The Electron Neutrino from Neutron Decay

The neutron is an unstable particle composition of a proton, electron, and an anti-electron neutrino, and when it ejects these particles.

$$n^0 \rightarrow p^+ + e^- + \overline{v}_e \tag{32}$$

By observation of the electron decay when its kinetic energy is zero, the maximum energy of the emitted neutrino, from the neutron can be determined, and thus the binding energy provided by the electron neutrino.[22]

From the excerpts of the paper on the details of nuclear particle structure [13], the vertex functions of both the neutron and the proton have been found. The proton vertex function Eq.(20), composed of three quark kernels.

$$\textit{Proton Vertex}\left(\frac{m_P}{m_e}\right) = \frac{1}{\sqrt{\left(\frac{\lambda_{PL}\eta^3}{\lambda_e}\frac{\bar{v}}{2^6}\right)\left(\frac{\lambda_{PL}\eta^3}{\lambda_e}\frac{\bar{v}}{1}\right)^{1/2}\left(\frac{\lambda_{PL}\eta^3}{\lambda_e}\frac{\bar{v}}{2}\right)^{1/2}}} \quad * \tag{33}$$

This calculates to have a proton mass equal to:

$$m_P = 1836.15267344223 \text{ electrons}$$

*Note that $\bar{v}_e$ is the electron rotation number noted in [Eq.(4)] not the neutrino energy $\bar{\nu}_e$

The vertex function for the Neutron from Eq.(21), is:

$$\textit{Neutron Vertex}\quad\left(\frac{m_N}{m_e}\right) = \sqrt{\frac{\left(\frac{\lambda_{PL}\bar{v}}{\lambda_e\eta^3}\right)}{\left(\frac{\lambda_{PL}\bar{v}}{\lambda_{eA}g^3}\right)}} \leftarrow \text{Electron Neutrino Vertex Function} \quad \frac{1}{\sqrt{\left(\frac{\lambda_{PL}\eta^3\bar{v}}{\lambda_e 2^6}\right)\left(\frac{\lambda_{PL}\eta^3\bar{v}}{\lambda_e}\right)^{1/2}\left(\frac{\lambda_{PL}\eta^3\bar{v}}{\lambda_e 2}\right)^{1/2}}} \tag{34}$$

Comparison shows the vertex function of the neutron contains the vertex function of the proton, and additional two kernels that are the ratio of an electron and a quark Kernel. That term is thus the vertex function of the emitted neutrino without kinetic energy.

Calculated Neutron Mass

The additional two kernels in Equation(34) constitute the ratio of an Electron Kernel and a Quark Kernel. Thus the mass of the Neutron is the product of the mass of the proton and the included term. It is concluded that the Electron Neutrino Vertex Function is:

$$\textbf{Neutrino Vertex Function}\ \frac{\bar{\nu}_e}{m_e} = \sqrt{\frac{\left(\frac{\lambda_{PL}\bar{v}}{\lambda_e\eta^3}\right)}{\left(\frac{\lambda_{PL}\bar{v}}{\lambda_{eA}g^3}\right)}} = \frac{1.000833802282540}{1.00083887131800 \text{ correct}}, \tag{35}$$

and the mass of the neutron is the binding energy and the mass of the electron:

$$\left(\frac{m_N}{m_e}\right) = \frac{m_P}{m_e}\times\frac{\bar{\nu}_e}{m_e} + m_e \quad = \frac{m_P}{m_e}\times 1.000833802282540 + m_e \tag{36}$$

Adding the electron then gives **the exact mass of the neutron** within experimental error to be:

$$m_N = m_e + m_P \times 1.000833802282540 \quad = 1838.68366173244 \tag{37}$$

The energy of the escaping neutrino energy $\bar{\nu}_e$ when the electron carries no kinetic energy is its binding energy, which is:

$$\bar{\nu}_e = \quad m_P \times 0.000833802282540 \quad = 1.53098829 \text{ electrons} \tag{38}$$

The mass energy of the Neutrino Vertex Function is in Eq.(35) is 1.000833802282 electrons, slightly more than an electron but when multiplied by the proton gives exactly the binding energy of the proton and the electron. (Eq.(38).) in the neutrino.
Note that the mass contribution is a product and if this neutrino were bound to an electron the mass addition would only be 0.0008338, thus we could suggest that this factor is the rest energy of the neutrino noted in Eq(31).
Presuming this is true the rest mass of the electron neutrino it is 0.000833802282540 electrons, or:

$$\overline{\nu}_{e0} = 426.06379529875 \text{ Ev} \tag{39}$$

The lateral rotation energy of the neutrino Eq. (31), doesn't correspond to the invariant mass energy of the electron neutrino as found by the Katrin experiment [25], that is less than 1 ev.

Muon Neutrino

The muon neutrino can be found by its expulsion from the pion. The pion decays into a muon, and a muon neutrino.

$$\pi^+ \rightarrow \mu^+ + \nu_\mu \tag{40}$$

The pion is thus a composition of the muon and a muon neutrino. It has a vertex function shown in, Equation(24), and the muon also has a vertex function as shown in Equation(22) .

Pion Vertex Function

The pion vertex structure at Equation (24) is:

Pion Vertex

$$\left(\frac{m_{\pi+}}{m_e}\right) = \sqrt{2}\frac{\left(\dfrac{\lambda_{PL}\overline{\boldsymbol{\nu}}_e}{\lambda_e g_A^2}\right)}{\left(\dfrac{\lambda_{PL}\overline{\boldsymbol{\nu}}_e}{\lambda_e \eta}\right)^2} = \frac{\alpha}{\left(\dfrac{\lambda_{PL}\overline{\boldsymbol{\nu}}_e}{\lambda_e \eta}\right)^2} \tag{41}$$

The value of the Fine Structure Constant in fundamentai constants is:

$$\alpha = \left(\frac{\sqrt{2}\lambda_{PL}\overline{\boldsymbol{\nu}}_e}{\lambda_e g_A^2}\right) \tag{42}$$

The vertex function of the Muon found in Ex.(22) is:

Muon Vertex

$$\left(\frac{m_\mu}{m_e}\right) = \frac{1}{\dfrac{1}{\sqrt{2}}\left(\dfrac{\lambda_{PL}}{\lambda_e \eta}\dfrac{\overline{\nu}_e 2^4}{}\right)\left(\dfrac{\lambda_{PL}}{\lambda_e \eta}\dfrac{\overline{\nu}_e 2^4}{}\right)} \tag{43}$$

Its decay products are:

$$\pi^+ \rightarrow \mu^+ + \nu_\mu \tag{44}$$

The vertex function of the muon EQ.(43), can be factored be from the pion vertex function in Equation(41), leaving:

$$\left(\frac{m_{\pi+}}{m_e}\right) = \left(\frac{m_\mu}{m_e}\right) \times \left(\frac{\lambda_{PL} \bar{\boldsymbol{\nu}}_e 2^8}{\lambda_e g_A^2}\right) = \left(\frac{m_\mu}{m_e}\right)(1 + .3209619104) \qquad (45)$$

The remaining term is then the Muon neutrino. The mass contribution to the pion due to the neutrino is then:

$$\left(\frac{m_\mu}{m_e}\right) \times .3209619104 \quad = 66.3647431366 \quad \text{electrons} \qquad (46)$$

When measured, this is reduced by: 8.062 electrons to 58.302 m_e due to the kinetic energy of the escaping muon. The value has been experimentally verified [23].
The expelled neutrino vertex function or the energy at rest in the pion is:

Neutrino expulsion energy
$$\frac{\nu_\mu}{m_e} = \left(\frac{\lambda_{PL} \bar{\boldsymbol{\nu}}_e}{\lambda_e g_A^2}\right) 2^8 = 675 \text{ Kev} \qquad (47)$$

The energy of the muon neutrino expelled is, 0.3209619104 electrons or 628.12 Kev.
Since the factor of 2^8 originated in the pion and is not included in the muon vertex it is presumed to be the kinetic energy ejected with the neutrino, thus from the proposed model the rest mass of the muon neutrino is the vertex in parenthesis in Equation(47) , and is :

$$\nu_{\mu 0} = 2.636 \text{ KeV} \qquad (48)$$

Tauon Neutrino

The tauon particle can decay into charged pion and a tau neutrino:

$$m_\tau \to m_{\pi+} + \bar{\nu}_\tau$$

There is a pion vertex function in Equation(24), and the pion in Equation,(41) thus the tauon neutrino vertex function can be arrived at by:

$$\left(\frac{m_\tau}{m_e}\right) = \left(\frac{m_{\pi+}}{m_e}\right) \bar{\boldsymbol{\nu}}_\tau = \left(\frac{m_\mu}{m_e}\right) \times \bar{\boldsymbol{\nu}}_\mu \bar{\boldsymbol{\nu}}_\tau \qquad (49)$$

That gives the value of the tauon neutrino vertex function:

$$\left(\frac{m_\tau}{m_e}\right) = \frac{m_{\pi+}}{m_e} \bar{\boldsymbol{\nu}}_\tau = \left(\frac{m_\mu}{m_e} \bar{\boldsymbol{\nu}}_\mu\right) \times \bar{\boldsymbol{\nu}}_\tau \qquad \to \bar{\boldsymbol{\nu}}_\tau = \left(\frac{m_\tau}{m_{\pi+}}\right) \qquad (50)$$

Tauon neutrino vertex energy is then:

$$\bar{\boldsymbol{\nu}}_\tau = \left(\frac{m_\tau}{m_{\pi+}}\right) = 12.7308 \text{electrons.} \qquad 41.986 \text{ kev} \qquad (51)$$

After the Tau decays only the pion remains thus the total ejection energy available is:
$m_\tau - m_{\pi+} = 3204.$ electrons or 1.637 Gev

Sketches of the charged pion and the neutrino are shown in appendix IV Fig.2a and 3a.

Summary Part Two

The neutrino vertex function represents energy of the neutrino's presence in a particle, and increases the total mass of that particle. The total ejection energy of the neutrinos depends on the mass to which it is bound and the rest mass of the ejected particles. It should be, but it is not clear that this is the relativist mass of the neutrino when it is moving, since it is not in agreement with ongoing experiments. [25]

The vertex energy/ mass of the neutrino is the energy of two electron photons equal to the mass of the electron, plus the rotational mass.
Presumably the neutrino can be slowed down by particle interaction, but at a minimum its interaction with its antiparticle must produce a positron-electron. Therefore its minimum energy is that of an electron.

Neutrino	Vertex Energy	Ejection Energy
Electron	426.023 ev	782.273 Kev
Muon	2.636 KeV	33.911 Mev
Tauon	41.986 kev	1.637 Gev

Conclusion

The particle mass numbers prove the concept. There are no arbitrary constants in the calculations, and if any values of the integers or the gyromagnetic ratios were off changed by one part in a hundred thousand the particle masses would be noticeably off in different directions. The agreement of the calculations with experimental values on so many particles proves the theory's merit
Delta-c Mechanics is a new approach to Physics Within the framework of the Feynman path integral approach to QED. It has no fields, and no forces. Particles interact by the mutually induced change the index of refraction to the action path probability flow.

The methods of Delta-c mechanics apply to all phenomena including centrifugal force, and gravitation, but standard theory produces equivalent results for most mechanical phenomena. The purpose of this paper has been to show accurate mass calculations for nuclear particles without the injection of arbitrary coupling constants, with results that are beyond question, and cannot be produced by any existing theory.
The Neutrino physical model is a bit speculative, but the vertex functions accurately produces the calculated mass of the neutron.

Authors Note

The material in Delta-c Mechanics developed by the author over a number of years is not for the casual observer. It is complicated and not likely to come onto the physics community's notice for a long time. Eventually however it will find its way, for it is a new formulation, and is the only theoretical approach that can produce the content of this paper.

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Appendix I

The Physical constants and Particle Mass Values from Codata and the Particle Data Group Used in this Paper

Particle	Particle Mass (gms)	Particle Mass (Electron)	Compton Radius (cm)
Electron	9.10938370150000E-28	1.0000000000000	3.86159267943989E-11
Muon	1.88353162700000E-25	206.7682829838260	1.86759430591295E-13
Proton	1.67262192369000E-24	1836.1526734400000	2.10308910326354E-14
Tauon	3.16754000000000E-24	3477.1882507793300	1.11055036503721E-14
Neutal Pion	2.40618001661378E-25	264.1430085130310	1.46193257250244E-13
Chgd Pion	2.48806333627759E-25	273.1319063734130	1.41381969273136E-13
Neutron	1.67492749804000E-24	1838.6836617324600	2.10019415509539E-14
Wboson	1.43344876621262E-22	157359.577023480	2.45399279311973E-16
Zboson	1.61700283014969E-22	177509.575086120	2.17542781991699E-16

1.00060127388753 Will this cause problem

	Physical Constants		
$\bar{\lambda}_{PL}$	Planck Radius	1.61640095996445E-33	(cm)
α	Fine Structure Constant	7.29735253594845E-03	
$\hbar$	Planck Constant	1.05457181760000E-27	(cgs)
c_0	Velocity of light	2.99792458000000E+10	(cm/sec)
ν_e	Electron Freq.	1.23558996386000E+20	(hz)
m_e	Electron Mass eV	5.10998902000000E+05	(ev)
G	Gravitational Constant	6.67550533180000E-08	$cm^3/gm\ sec^2$
	Composit Constnts		
$\bar{\nu}_e$	Electron cycle number	1.23558996386000E+20	Eq 4
E_0	Nuc Atom Ground State	2.67493983646500E-05	Eq 5
$\mathfrak{R}_0$	ECR Radius	2.82447977709503E-13	(cm)Eq 3
g_A	Anom Gyromagnetic Ratio	1.00115965218073	eq 11
η	Nuclear Anomalous Spin	1.00060014721177	Eq 12

Appendix II

Eddington

From Sir Arthur Eddington's book Relativity Theory of Photons and Electrons, 1936 on wavefunctions.
Multiplication of Probabilities
It is of course entirely **opposed to our habit of thought to regard a system as the product of its parts rather than the sum of its parts.** Therefore **we have a long way to travel before we can connect the combination of systems by multiplications** with our ordinary outlook.
Admitting that multiplication is the primary operation in the theory (QM), the prevalence of exponentials and the formula which we have developed indicates that the way in which the subsidiary operations of addition arise. We see that in general the **additive quantities of physics must occur in** exponentials.

Appendix III

Deficit Energy

Observation of the vertex function that makes up the mass of particles it is apparent that, except for QED effects, the core of all is the same as the electron. It is thus presumed that vertex Kernels are electrons occupying different states.

When an electron falls into the ground state of hydrogen the energy of that state, (12.6 ev) is radiated away. The mass of the electron in that state is reduced by:

$$m' = m_e\left(\alpha^2 / 2\right) \tag{52}$$

The particle created, Δm, a photon that is radiated away is in fundamental terms:

$$\frac{\Delta m}{m_e} = \left(\frac{1}{2}\left[\frac{\Re_0}{\lambda\!\!\!^{-}_e n_R}\right]^2\right) \tag{53}$$

The particles are attractive and on locking into a state radiate the energy away as a photon leaving the reduced electron m' bound in the state.

$$\frac{\Re_0}{\lambda\!\!\!^{-}_e n_R} = \frac{L}{\hbar\, n_R} \tag{54}$$

Nuclear particles operate somewhat the same; this can be demonstrated with the vertex function of the Muon. From Eq.(22), with some rearranging the vertex function is:

$$\frac{m_\mu}{m_e} = \frac{1}{\frac{1}{\sqrt{2}}\left(\frac{\Re_0}{\lambda\!\!\!^{-}_e}2^4\right)\left(\frac{\Re_0}{\lambda\!\!\!^{-}_e}2^4\right)} = 207.\text{electrons} \tag{55}$$

When the two vertexes come together, the energy of the binding creates the muon, but unlike the atomic particles in Eq.(53), there is nothing from which to draw the energy. The particles are repulsive and the energy to create the particles has to be injected by inertia or pressure. Once the particles ae bound however, the deficit of angular momentum holds the particles together and the energy of the binding is radiated away.

The particles inertial mass exists as a deficit of energy. The Einstein mass energy relation would then be mass created by a deficit of energy:

$$mc_0^2 = -\,\varepsilon \tag{56}$$

Energy has not been lost, but escaped to the universe. For a particle to be extracted from a nuclear state requires the energy equivalent to its mass be restored. Once restored can eject a free electron.

This relation provides the energy balance in the universe between the inertial mass, and electromagnetic energy.

Appendix IV

Illustrated Supplement

A graphical illustration of the significant aspects of the vertex functions is presented here to better give an understanding of the process.

Noting that the Eddington view of the mass as a product of mass functions, in this case the vertex kernels are the mass components of the vertex functions.

$$\left(\frac{m}{m_e}\right)=\left(\frac{m}{m_e}\right)\left(\frac{m}{m_e}\right)\left(\frac{m}{m_e}\right)\bullet\bullet\bullet \qquad (1.57)$$

We can illustrate the relation between the atomic and nuclear vertex functions, by comparing the atomic vertex function, the Muon vertex function, the function of the lowest energy nuclear particle. From the text:

$$\frac{\varepsilon_R}{\varepsilon_e}=\frac{1}{2}\left(\frac{\alpha}{n_R}\right)^2=\frac{1}{2}\left(\frac{\Re_0}{\lambda_e g_A^2 n_R}\right)^2 \quad \sim \quad \rightarrow \quad \left(\frac{L_e}{\hbar\ n_R}\right)^2$$
$$\left(\frac{m_\mu}{m_e}\right)=1\ \Big/\left[\ \frac{1}{\sqrt{2}}\left(\frac{\lambda_{PL}\overline{v}_e}{\lambda_e\eta}\frac{2^4}{}\right)\left(\frac{\lambda_{PL}}{\lambda_e\eta}\frac{\overline{v}_e 2^4}{}\right)\right] \quad \sim \rightarrow \left(\frac{\hbar}{L_e n_N}\right)^2 \qquad (1.58)$$

The ratio of the electron creation radius to the electron Compton radius is actually the ratio of its angular momentum to the Planck constant $\Re_0 / \lambda\!\!\!^- = \Re_0 m_e c_0 / \hbar = L_e / \hbar$. This is ratio of the angular momentum of the electron orbiting at the electron creation radius to the Planck action $\hbar$.

$$\text{Atomic (Rydberg } n_R = 1\text{) state} \qquad \frac{\varepsilon_R}{\varepsilon_e} \rightarrow \left(\frac{\Re_0}{\lambda\!\!\!^-_e \; n_R}\right)^2 \rightarrow \left(\frac{1}{193.3 n_R}\right)^2 = 13.6\text{ev} \tag{1.59}$$

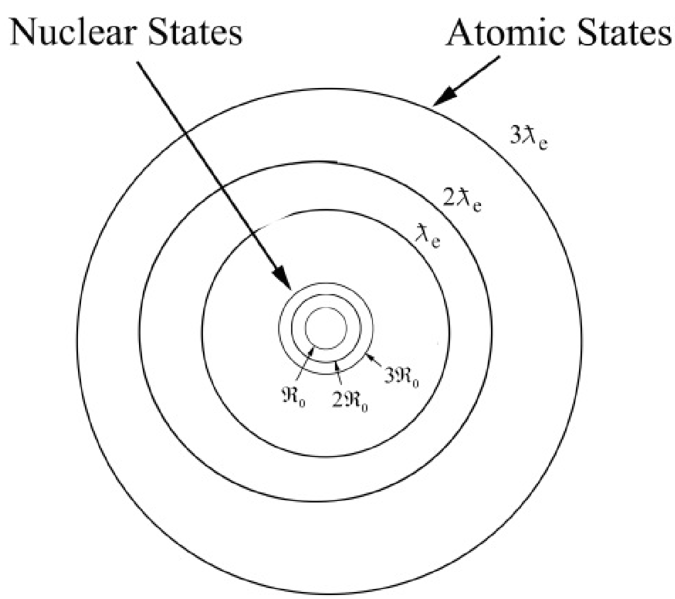
$$\text{Nucler (Muon } n_N = 16\text{) states} \qquad \frac{m_\mu}{m_e} \rightarrow \left(\frac{\lambda\!\!\!^-_e}{\Re_0 n_N}\right)^2 \rightarrow \sqrt{2}\left(\frac{193.3}{n_N}\right)^2 = 207$$

Note the mass energy of the atomic Rydberg states, and the mass of the nuclear state are virtually reciprocals.

Atomic states have integral values of $n\hbar$ whereas nuclear states have fractional values $\hbar / n$ .The illustration of the position of the atomic and nuclear states are illustrated in Fig. 1A

Fig. 1A

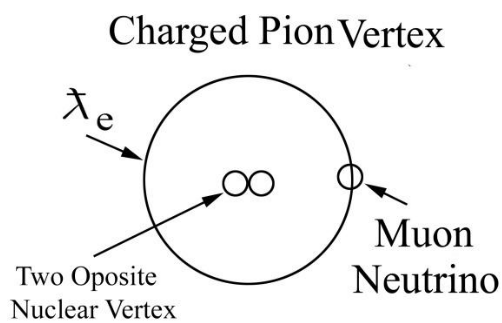
Relative locations of Atomic, and Nuclear states showing the consilience between the atomic (photon) and nuclear inertial mass (particle)



The similarity of the neutron and charged pion are illustrated in Fig. 1A and. 2A.

Fig2A. **Fig. 3A**

Relative locations of states
in the charged pion



Relative locations of states
in the Neutron